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LINE X TESTER ANALYSIS FOR YEILD AND ITS COMPONENT AND GRAIN QUALITY CHARACTERS IN RICE

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ABSTRACT

A Study on combining ability and heterosis were conducted on 12 F_1 hybrids along with seven rice genotypes field experiment was carried out at the Farm of Rice Research and Training Center, Sakha, Kafr El-sheikh, Egypt using to line x tester mating design, during 2012 and 2013 seasons. The objectives of this investigation was aimed to know the pattern of inheritance of some grain yield and its component and grain quality characters in rice for selecting superior genotypes. The present investigation. The Line, GZ 8455-6-8-3-1was earlier and shorter than other linens, its estimated values of days to complete heading and plant height were (99 days and 96.24 cm), respectively. Among the linens, GZ 8372-13-1-3-1 followed by GZ 8455-6-8-3-1. were found to be longest panicle length, highest number of panicle per plant, lowest sterility %, heaviest 100 grain weight and highest grain yield per plant. On the other hand, Sakha 103 and Sakha 102 were found to be the earliest Testers. Moreover, Sakha 101 was found to be the shortest tester. In addition GZ 8455-6-8-3-1 x Sakha 102 followed by GZ 8455-6-8-3-1 x Sakha 104 were the earliest rice cross combinations. While, the shortest plant height (98.14 cm) was lasted from GZ 8455-6-8-3-1 x Sakha 102.

Analysis of variance revealed significant differences among genotypes, crosses, lines, testers and line x tester interactions for yield and its component and grain quality characters. Both GCA and SCA Variances were highly significant for all the studied characters indicating the predominance of additive and non additive gene action in the inheritance of all characters. The estimated ratio of GCA/SCA was lower than unity for all the studied traits except days to complete heading trait, indicating the importance of non-additive gene action in the inheritance of all traits, except days to complete heading trait, which was fond to be controlled by additive gene action. The highest heterobeltiosis were obtained for cross GZ8951-9-7-1-3 x Sakha 103 followed by GZ 8951-9-7-1-3 x Sakha 102, GZ 8951-9-7-1-3 x Sakha 101 and GZ 8951-9-7-1-3 x Sakha 102 rice crosses for number of panicles/plant and head rice %, respectively. The proportional contribution of testers was observed to be higher than that of the interactions of line x tester that revealed the highest estimates of GCA variance.

The cross combinations GZ 8951-9-7-1-3 x Sakha 101, GZ 8455-6-8-3-1 x Sakha 104, GZ 8455-6-8-3-1 x Sakha 101, GZ 8951-9-7-1-3 x Sakha 103, GZ 8372-13-1-3-1 x Sakha 104 and GZ 8372-13-1-3-1 x Sakha 101 were observed to be good specific cross combinations for grain yield and grain quality characters to their highly significant SCA and heterobeltiosis effects. High broad sense heritability (96.23%) was recorded for days to complete heading. While high narrow sense heritability was recorded for number of filled grains / panicle (50.14%). Highest estimates of expected genetic advance were observed for gel consistency and 100 grain weight. Highly significant and positive estimates of phenotypic correlation coefficient were found between grain yield and each of hulling %, milling %, head rice %, grain elongation, gel consistency and gelatinization temperature.

Keywords: Rice, Line x Tester, heterobeltiosis, combining ability, yield, its component and grain quality traits

INTRODUCTION

Rice occupies an important position in the Egyptian economy. The total area under rice is about 1.10 million Fadden producing about 6 million tones of paddy rice. Breeding strategies based on selection of hybrids require expected level of heterosis as well as the specific combining ability (SCA). The rice breeders often face with the problem of selecting parents and crosses for improving high yielding rice varieties. Combining ability analysis is one of the powerful tools available select the desirable parents and crosses for the exploitation of heterosis (Sarker *et al*., 2002; Radish *et al*., 2007). Presence of heterosis and SCA effects for yield and itsrelated traits are reported by Nuruzzaman *et al*., 2002; Faiz *et al*., 2006 and saleem *et al*., 2008. To exploit maximum heterosis using the hybrid programme, we must know the combining ability of different lines and restorers. The performance of parent may not necessarily reveal it to be a good or poor combiner. Therefore, gathering in formation on nature of gene effects and their expression in terms of combining ability is necessary. At the same time, it also elucidates the nature of gene action involved in the inheritance of characters. General combining ability (GCA) is attributed to additive gene effects and additive x additive epistasis and is theoretically fixable. On the other hand, specific combining ability attributable to non-additive gene action may be due to dominance or epistasis or both and is non-fixable. The presence of non-additive genetic variance is the primary justification for initiating the hybrid program (Cockerham, 1961; Pradhan *et al*., 2006). There is need to study various morphological traits to get better understanding of inheritance and select or identify superior genotypes. (Mishra and Verma 2002, Mahto *et al*., 2003 and Swati and Ramesh, 2004). Heterosis estimates were attributed to both additive and high degree of dominance or epistasic interactions and both for one or more yield, its component and grain quality characters. Vanaja and Babu (2004) pointed out that yield increase in rice was due to favorable heterosis in number of grains per panicle. In this paper an attempt has been made to assess the combining ability and to determine the nature and magnitude of gene action for yield and its related and grain quality characters to explore the best combination of hybrids for the exploitation of maximum heterosis or hybrid vigor in F1 hybrids for yield and its component (days to complete heading, plant height, panicle length, number of panicles per plant, number of filled grains per panicle, sterility %, 100 grain weight and grain yield traits), and grain quality characters (grain shape, hulling % milling %, head rice %, grain elongation %, gel consistency, gelatinization temperature and amylose content %).

MATERIALS AND METHODS

Plant materials

The experimental materials comprised seven rice genotypes, three genotypes (GZ 8372-13-1-3-1, GZ 8951-9-7-1-3 and GZ 8455-6-8-3-1) were used as females (designated as lines for high yielding ability, good grain quality and blast resistance) and four genotypes (Sakha 101, Sakha 102, Sakha 103, Sakha 104) were used as males. These parents were crossed to produce 12 F_1 hybrids using to line x tester mating design (Kempthorne, 1957). This study was conducted during 2012 and 2013 seasons at Sakha Farm Station, Sakha Kafr El-sheikh, Egypt. Single seedlings of each entry were transplanted in 20 x 20 cm spacing at 3 x 5 m^2 plots in a randomized complete block design with three replications. The agronomic practices were done as recommended. In this study, eight characters, viz, yield and its component includes days to complete heading, plant height (cm), panicle length (cm), number of panicles per plant, number of filled grains per panicle, sterility percentage and grain yield per plant, these mentioned traits were evaluated based on standard evalution system of rice (Scshu, 1988). Eight grain quality characters includes grain shape, hulling%, milling %, head rice %, grain elongation, gel consistence, gelatinization temperature and amylose content %. The last three traits were evaluated by Cagampang *et al* (1973), Little *et al*. (1958) And Williams *et al*.(1958).

Statistical analysis

Data were recorded on twenty randomly selected plants from parents and F_1s plant samples. Combining ability analysis was done using line x tester method (Kempthorne, 1957). The variances for general combining ability and specific combining ability were tested against their respective error variances derived from ANOVA reduced to mean level. Significance test for GCA and SCA effects were performed using t-test. Heterobeltiosis and Heritability were determined as outlined by Falconar and Mackay (1996). Expected genetic advance was calculated by Johanson *et al* (1955). Phenotypic correlation coefficient was performed according to Dewey and Lu (1959).

RESULTS AND DESICATION

Means performance

Means of lines, testers and their hybrids for yield and its components were reported in Table 1 indicated worth of genetic variability for the improvement each of days to complete heading, plant height (cm), panicle length (cm), number of panicles per plant, number of filled grains per panicle, sterility percentage and grain yield per plant which are important in rice yield. Line, GZ 8455-6-8-3-1was earlier (99 days) than other lines and shortest one (96.24 cm) in plant height. Longest panicle length, highest number of panicles per plant, lowest sterility %, heaviest 100grain weight and grain yield per plant were recorded for GZ 8372-13-1-3-1 and GZ 8455-6-8-3-1. Also Sakha 102 tester was earlier than the other testers follwed by Sakha 103. While Sakha 101 is the shortest tester. follwed by Sakha 103. longest panicale, highest number of panicles, number of filled grains per panicle, 100 grain weight and grain yield per plant were recorded from testers, Sakha 101 and Sakha 104, respectively. On the contrary, lowest sterility percentage was obtained from tester of sakha 102. The earliest cross combinations were obtained for GZ 8455-6-8-3-1 x Sakha 102 followed by GZ 8455-6-8-3-1 x Sakha 104. While the shortest plant hight was lasted from GZ 8455-6-8-3-1 x Sakha 102 (98.14 cm) followed by GZ 83951-9-7-1-3 x Sakha 101 (100.47cm). On the other hand, the longest panicle length was obtained from GZ83951-9-7-1-3 x Sakha 101 (27.51 cm). followed by GZ 8951-9-7-1-3 x Sakha 102 (26.85 cm). Highest number of panicles per plant, number of filled grains per panicle, 100 grain weight and grain yield per plant were recorded for GZ 8951-9-7-1-3 x Sakha 101, GZ8972-13-1-3-1 x Sakha 104 and GZ8951-9-7-1-3 x Sakha 104, respectively.

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Means of lines, testers and their hybrids for grain quality characters (Table 2) showed that wide of genetic variability for the improvement of grain shape, hulling%, milling%, head rice %, grain elongation%, gel consistency, gelatinization temperature and amylose content %. Highest mean values of grain shape, hulling%, milling%, head rice%, grain elongation%, gel consistency, gelatinization temperature were obtained from lines GZ 8951-9-7-1-3 and GZ 8455-6-8-3-1, respectively but GZ 8455-6-8-3-1 was the lowest one for amylose content %. Testers, Sakha 102 and Sakha 103 gave highest mean values for grain shape. On the other hand, tester Sakha 101 gave highest mean values for hulling%, milling% and head rice %. While the longest grain was recorded from Sakha 103 (0.83cm). Whereas the best gel consistency was obtained from Sakha 103 followed by Sakha 104 tester. Concerning cross combination, the bold grain shape (2.74), (2.65) and (2.64) were lasted from three crosses GZ 8372-13-1-3-1 x Sakha 102, GZ 8455-6-8-3-1 x Sakha 103 and GZ8455-6-8-3-1 x Sakha 101, respectively. The highest main of hulling%, milling% and head rice % were obtained from GZ 8372-13-1-3-1 x Sakha 104 and GZ8951-9-7-1-3 x Sakha 101 crosses. While the longest mean of grain elongation was recorded from GZ8372-13-1-3-1 x Sakha 103 followed by GZ 8372-13-1-3-1 x Sakha 101. On the other hand, the cross GZ 8951-9-7-1-3 x Sakha 103 gave the highest mean of gelatinization temperature. Whereas, low gelatinizing temperature and amylose content % were obtained from GZ 8455-6-8-3-1 x Sakha 103.Significant differences among various traits have been reported by Surek and Korkut, (2002); Swati and Ramesh, (2004) and El-Abd *et al* (2007). Their results showed that different genetic systems involved in controlling characters, which emphasized on important of study of these characters.

Combining ability analysis

There were significant differences among studied genotypes for yield and attributes as well as grain quality characters (Table 3 and 4) due to analysis of variance, which lead to the combining ability analysis. Thus were partitioned genetic effects between genotypes into General Combining Ability and Specific Combining Ability. Therefore, for days to complete heading and plant height negative GCA and SCA effects were desirable, while in case of other characters positive GCA and SCA effects were desirable.

Analysis of variance of combining ability for yield and its component and grain quality characters are presented in Tables 3 and 4. Analysis of variance of combining ability for yield, its component and grain quality characters revealed significant differences among genotypes, crosses, lines, testers and line x tester interactions. The significant differences among the lines, testers and lines x testers indicated that the genotypes had wide genetic diversity among themselves for all traits. The significant of the means of sum of squares due to lines and testers indicated a prevalence of additive variance. However, significant differences due to interactions of line x tester for all the characters, indicating the importance of both additive and non-additive variance. Variances of SCA were higher than the GCA variances for yield, its component and grain quality characters except for days to complete heading and gel consistency which indicated preponderance of non-additive gene action in the inheritance of the traits.

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This was further supported by low magnitude of gca/sca ratios (Table 3 and 4). It suggested greater importance of non-additive gene action in its expression and indicated very good prospect for the exploitation of non-additive genetic variation for traits through breeding program (Ramalingam, 1997; Annadurai and Nadarajan 2001 and El-Abd *et al* 2007).

General combining ability effects:

General combining ability effects of lines and testers for yield and its component characters are presented in Table 5. Variation in general combining ability (GCA) effects was estimated among lines and testers for eight plant characters of yield and its component to identify the best parent for subsequent hybrid development program. The results of days to complete heading and plant height showed negative GCA effects, while in case of other characters positive GCA effects are desirable. Minimum plant height is needed to protect the crop from lodging. Therefore, GZ 8951-9-7-1-3 was a potential female parent and has highly significant GCA effect in the desirable direction (negative direction) for days to complete heading and plant height. These findings are in accordance with Sarker *et al*., (2002). The female line, GZ 8951-9-7-1-3 indicated highly significant GCA effects for panicle length, number of panicle per plant, number of filled grains per panicle, 100 grain weight and grain yield per plant. These results are in conformity with Singh and Kumar (2004) and El-Abd *et al* (2007).

Among testers Sakha 102 is the potential male parent having negative and highly significant GCA effects for days to complete heading and plant height thus confirming the findings of Roy and Mandal (2001) and Shehata, (2004). Among testers, positive GCA effects are important for panicle length. Therefore the tester Sakha 102 having the positive and highly significant GCA effect was the potential parent which the selection will be effective for their efficient use in subsequent hybrids development with more longest panicle length. These results are in line with Roy and Mandal (2001) and Sarker *et al*. (2002). The male parents Sakha 101 and Sakha 104 showed highly significant GCA effects for number of panicles per plant, number of filled grains per panicles, 100 grain weight and grain yield per plant. respectively. However, Sakha 102 indicated negative and highly significant GCA effect for sterility %.

General combining ability effects of lines and testers for eight grain quality characters are presented in Table 6. Variation in general combining ability (GCA) effects was estimated among lines and testers. The results of gelatinization temperature and amylose content % showed negative GCA effects, while in case of other characters positive GCA effects are desirable. Therefore, GZ 8372-13-1-3-1 and GZ8951-9-7-1-3 is a potential female parent and has highly significant GCA effect in the desirable direction for gelatinization temperature and amylose content %. The female line GZ 8951-9-7-1-3 indicated highly significant GCA effects for hulling % milling %, head rice %, grain elongation % and gel consistency traits.

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Concerning testers Sakha 104 was the potential male parent having positive and highly significant GCA effects for grain shape, hulling % milling %, head rice %, grain elongation %, gel consistence and negative highly significant for gelatinization temperature and amylose content %. Among testers, positive GCA effects are important for panicle length. Therefore the tester Sakha 104 having the positive and highly significant GCA effect. The potential parent wherein the selection will be effective for their efficient use in subsequent hybrids development.

Specific combining ability effects:

The estimates of specific combining ability effects of 12 rice hybrids for yield and its component are presented in Table 7. Low days to complete heading and Minimum plant height was desirable trait of rice crop. The cross GZ 8372-13-1-3-1 x Sakha 104 was the best showing negative and significant combining ability effect of -6.26 and -7.41 for days to complete heading and plant height respectively. The results confirm the findings of Rogbell *et al*. (1998), Roy and Mandal (2001), Sarker *et al*. (2002), Shehata (2004). and El-Abd *et al* (2007). Increased panicle length and more number of panicles per plant were also a desirable trait of rice hybrids with increased yield/plant. The cross combinations namely GZ 8951-9-7-1-3 x Sakha 104 and GZ 8455-6-8-3-1 x Sakha 104 possess highly significant and positive SCA effects for panicle length and number of panicles per plant. These studies was in conformity with the reports of El-Abd *et al* (2007). The positive and significant SCA effect for number of filled grains per panicle was recorded in five crosses combinations i.e., GZ 8372-13-1-3-1 x Sakha 104, GZ 8951-9-7-1-3 x Sakha 104, GZ 8372-13-1-3-1 x Sakha 101, GZ 8453-6-8-3-1 x Sakha 101 and GZ 8453-6-8-3-1 x Sakha 104, whereas GZ 8372-13-1-3-1 x Sakha 104 and GZ 8453-6-8-3-1 x Sakha 104 exhibited negative and highly significant SCA effects for sterility %, while GZ 8453-6-8-3-1 x Sakha 102 have highly significant positive SCA effect for 100-grain weight. These results are in line with the findings of Roy and Mandal (2001) and Singh and Kumar (2004). The grain yield/plant is an ultimate objective of rice breeding and hybrid development programs. The cross combinations GZ 8951-9-7-1-3 x Sakha 101, GZ 8455-6-8-3-1 x Sakha 104, GZ 8455-6-8-3-1 x Sakha 101, GZ 8951-9-7-1-3 x Sakha 103, GZ 8372-13-1-3-1 x Sakha 104 and GZ 8372-13-1-3-1 Sakha 101 revealed positive and highly significant SCA effects for yield/plant. This is in agreement with the results obtained by Ganesen and Rangaswamy (1997), Roy and Mandal (2001), Sarker *et al*., (2002) and Singh and Kumar (2004).

The estimates of specific combining ability effects of 12 rice hybrids for yield and its component are presented in Table 8. The results showed highly significant and positive SCA for grain shape was obtained from GZ 8372-13-1-3-1 x Sakha 104 and GZ 8455-6-5-3-1 x Sakha 104. While highly significant and positive SCA for hulling %, milling % and head rice % were recorded from GZ 8372-13-1-3-1 x Sakha 104, GZ 8455-6-5-3-1 x Sakha 104 and GZ 8455-6-5-3-1 x Sakha 101 crosses respectively. Longest of grain elongation was desirable trait of rice grain quality, there for highly significant and positive SCA was recorded from GZ 8455-6-8-3-1 x Sakha 102 and GZ 8455-6-8-3-1 x Sakha 104 crosses. On the contrary, cross combinations namely, GZ 8455-6-8-3-1 x Sakha 104 possess highly significant and negative SCA effects for gelatinization temperature and amylose content %.

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The information on the nature of gene action with respective variety and characters might be used depending on the breeding objectives. Investigation of GCA effects revealed that among lines and testers were good general combiners for grain yield and the other traits. Hence these good general combiners of males and females may be extensively used in future for hybrid rice breeding program. Determine the usefulness of a particular cross combination in the exploitation of heterbeltosis. In the present study, SCA effects in six crosses were highly significant and positive for grain yield. Majority of these hybrids involved at least one parent with positive GCA effect. Similar results have been reported by Rao *et al*. (1996).

Among the six crosses GZ 8951-9-7-1-3 x Sakha 101, GZ 8455-6-8-3-1 x Sakha 104, GZ 8455-6-8-3-1 x Sakha 101, GZ 8951-9-7-1-3 x Sakha 103, GZ 8372-13-1-3-1 Sakha 104 and GZ 8372-13-1-3-1 Sakha 101 which depicted highly significant positive SCA effects for grain yield, only one crosses(GZ 8951-9-7-1-3 x Sakha 101) showed high heterobeltiosis (Table 9). Dhaliwal and Sharma (1990) reported that non-additive gene effects were predominant for yield and its components. It is evident that cross combinations, which expressed high SCA effects for grain yield have invariably exhibited positive SCA effects for one or more yield related traits also. While selecting the best specific combination for yield, it would be important to give due weight age to yield related traits. Grafius (1959) had already suggested that there is no separate gene for yield, but yield is an end product of multiplicative interaction among various yield components.

Heterosis:

Percent heterobeltosis was calculated for eight yield, its components (Table 9). The degree of heterobeltosis varied from cross to cross and from character to character. Alam *et al*., (2004) and Shehata, S.M (2004). negative heterobeltiosis was desirable for days to complete heading and plant height but for rest of the characters positive heterobeltiosis was desirable. Highly significant and negative heterobeltiosis were lasted from crosses combination GZ 8455-6-8-3-1 x Sakha 101 and GZ8455-6-8-3-1 x Sakha 104. Positive heterobeltosis and highly significant for panicle length was recorded from GZ 8372-13-1-3-1 x Sakha 104 and GZ 8951-9-7-1-3 x Sakha 101. While highly significant and positive heterobeltiosis for number of panicles per plant was recorded from GZ 8951-9-7-1-3 x Sakha 103 followed by GZ 8951-9-7-1-3 x Sakha 102. On the other hand highly significant and positive heterobeltosis for number of field grains / panicle, 100 grain weight and grain yield were recorded from GZ8372-13-1-3-1 x Sakha 104 and GZ8951-9-7-1-3 x Sakha 101 respectively. The results were agreed with Watanesk (1993), Rao *et al*., (1996), Li *et al*., (1997), Perera *et al*., (2001), Nuruzzaman *et al*., (2002) and El-Abd *et al* (2007).

Percent heterobeltosis was calculated for eight grain quality characters (Table 10). Highest significant and positive degree of heterobeltosis for grain shape, hulling%, milling% and head rice% were recorded from GZ 8455-6-8-3-1 x Sakha 101 cross. While highly significant and positive heterobeltosis for grain elongation and gel consistence were leasted from GZ 8455-6-8-3-1 x Sakha 102 cross. on the contrary highly significant and negative heterobeltosis for gelatinization temperature and amylose content % was obtained from cross GZ8455-6-8-3-1 x Sakha 101.

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In view of this, it appears that heterobeltosis for yield may be through heterobeltosis for individual yield components or alternatively due to multiplication effects of non-additive gene effects of component characters. Generally, high x high, low x high and high x low general combiner parents produced good specific cross combinations. In these crosses additive x additive, dominance x additive and additive x dominance type of gene action was found. In cases, high x high general produced inferior cross combinations indicating epistatic type of gene action for these traits. Six good specific cross combinations GZ 8951-9-7-1-3 x Sakha 101, GZ 8455-6-8-3-1 x Sakha 104, GZ 8455-6-8-3-1 x Sakha 101, GZ 8951-9-7-1-3 x Sakha 103, GZ 8372-13-1-3-1 x Sakha 104 and GZ 8372-13-1-3-1 x Sakha 101 might be released as promising lines for commercial utilization after further study. Ultimate aim of breeding is to gain the heterotics yield associated with other heterotic characters. Yield is the complex character of all other yield contributing characters. Percent better parents were calculated for grain yield and seven yield related traits (Table 9). The degree of heterosis varied from cross to other and from character to other. Concerning days to complete hading, plant height, gelatinization tempreture and amylose content negative heterobeltosis were desirable but for rest of the characters positive heterobeltosis were desirable. Desirable and significant heterobeltosis for grain yield was found in five crosses namely, GZ 8951-9-7-1-3 x Sakha 101, GZ 8455-6-8-3-1 x Sakha 104, GZ 8455-6-8-3-1 x Sakha 101, GZ 8951-9-7-1-3 x Sakha 103, GZ 8372-13-1-3-1 x Sakha 104 and GZ 8372-13-1-3-1 x Sakha 101 associated with higher heterosis for most of the yield related traits.

Estimates of heritability and expected genetic advance:

It is clear from Table (11) that Heritability in broad sense estimates (h^2b.) were higher than their corresponding ones of narrow sense heritability (h^2n.) for all studied characters. High broad sense heritability (96.23%) was recorded for days to complete heading. It was found to be moderate (79.54%) for milling % and to high for panicle length (95.86%). High narrow sense heritability was recorded for number of filled grains/panicle (50.14%), while it was ranged from low to moderate, in other remaining grain yield and gain quality traits. The variation among the heritabilities in both broad and narrow sense values might be due to either gene expression of the trait. The results also revealed that the magnitude of heritability in narrow sense was lower than its corresponding for all studied characters, suggesting the increase contribution of additive gene effect. Additive gene affects increased in the subsequent generation, which help the breeders to select the best genotypes in this generation. So, these materials could successfully be used in the rice breeding program.

The highest estimates of expected genetic advance were observed for gel consistency and 100 grain weight. While, the low estimates were detected for amylose content %, indicating that additive genetic variance played an important role in the inheritance of these traits. Moreover, low to moderate estimates of heritability in narrow sense, accompanied with low to moderate expected genetic advance were recorded for most of the studied traits, lead to conclude that effectiveness of selection of most studied traits might be practiced in the advanced generations. These results wire in harmony with those of Abd-Allah (2000), Abd El-Aty *et al*. (2002), Hammoud *et al*. (2006) Abd El-Lattef and Badr (2007) and Abdel-latef *et al.,* (2011).

Table 11. Estimates of broad (h^2b) and narrow (h^2n) sense heritability' % and expected genetic advance (GS%) for grain yield and grain quality characters.

Characters	h^2b	h^2n	GS%
Days to complete heading (days)	96.23	42.23	22.45
Plant height (cm)	91.54	39.26	19.43
Panicle length (cm)	95.36	40.12	11.24
No. of panicles /plant	91.45	41.28	15.36
No. of filled grains /panicle	85.47	50.14	12.64
Sterility %	94.58	35.26	13.29
100-grain weight(g)	74.26	31.54	12.54
Grain yield/plant	86.59	49.38	25.98
Grain Shape%	90.12	35.48	22.57
Hulling %	83.54	40.15	13.45
Milling %	79.54	39.57	24.59
Head Rice %	85.47	22.35	21.57
Grain Elongation %	90.34	36.48	17.36
Gel Consistence	92.56	30.54	26.48
Gelatinization Temperature	83.35	24.18	18.67
Amylose content %	94.28	32.49	9.27

Estimates of phenotypic correlation coefficient:

Phenotypic correlation coefficients among all possible pars of the studied traits are presented in (Table 12). Highly significant and positive estimates of phenotypic correlation coefficient were found between grain yield and each of hulling %, milling %, head rice %, grain elongation, gel consistency and gelatinization temperature, while, it was significantly and positively associated with amylose content %. While, it was found to be highly significantly and positively associated between number of filled grains / panicle and hulling %, milling % and head rice. Moreover, significant and positive estimates of phenotypic correlation coefficient were recorded for 100 grain weight with milling % and head rice %. Sterility % was negatively correlated with milling and head rice %. However, insignificant either positive or negative estimates of phenotypic correlation coefficient were recorded among other remaining traits. These results ware in agreement with those of Abd- Allah (2000), Abd El-Lattef *et al*. (2006) El-Abd *et al.* (2007) and Abdel-latef *et al.,* (2011).

Table 12. Estimates of phenotypic correlation coefficients among between grain yield an grain quality characters.

Characters	Hulling %	Milling %	Head Rice %	Grain Elongation %	Gel Consistence	Gelatinization Temperature	Amylose content %
Plant height (cm)	0.22	0.21	0.26	0.17	0.22	0.25	0.18
Panicle length (cm)	0.29	0.18	0.25	0.22	0.24	0.18	0.21
No. of panicles /plant	0.32*	0.25	0.28	0.18	0.28	0.21	0.16
No. of filled grains /panicle	0.38**	0.36**	-0.42**	0.21	0.18	0.29	0.22
Sterility %	0.36**	-0.38**	-0.39**	0.22	0.14	0.24	0.23
100-grain weight(g)	0.28	0.32*	0.36**	0.28	0.35**	0.36**	0.22
Grain yield/plant	-0.42**	-0.36**	-0.40**	0.38**	0.41**	0.38**	0.32*

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تحليـل السـلالات والسـلالات الاخويــة لمحصــول الارز ومكوناتــة وصـفات الجـودة للحبوب

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اجريت دراسة القدرة على التآلف وقوة الهجين مقارنة باقضل الاباء لمحصول الحبوب باستخدام نظام السلالات والسلالات الاخوية حيث تم استخدام ٧ تراكيب وراثية ثلاثة منها استخدمت كامهات وهى (GZ 8372-13-1-3-1, GZ 8951-9-7-1-3 and GZ 8455-6-8-3-1) واربعة تم استخدامهم كاباء وهى سخا ١٠١ و سخا ١٠٢و سخا ١٠٣و سخا ١٠٤ وذلك بهدف انتاج ١٢ تركيب وراثي مختلف بغرض دراسة توارث صفات المحصول والجودة للحبوب وذلك بمحطة البحوث الزراعية بسخا أثناء موسمى ٢٠١٣ و٢٠١٢.

وكانت أهم النتائج المتحصل عليها كالا تى:-

١-اوضحت النتائج تفوق السلالة جى زد ٨٤٥٥-٦-٨-٣-١ فى صفة التبكير وطول النبات مقارنة بباقى السلالات بينما تفوقت السلالتين جى زد ٨٣٧٢-١٣-١-٣-١ و جى زد ٨٤٥٥-٦-٨-٣-١ فى كل من صفات طول الدالية وعدد الداليات بالنبات الفردى والنسبة المؤوية للعقم و ووزن المائة حبة و محصول الحبوب بالنبات الفردى. اشارت النتائج تفوق الصنف سخا ١٠٢ فى صفة التبكير بينما تفوق الصنف سخا ١٠١ فى صفة طول النبات الفردى. تفوق الهجين جى زد ٨٤٥٥-٦-٨-٣-١ x سخا ١٠٤ فى صفة التبكير بينما جاء الهجين جى زد ٨٤٥٥-٦-٨-٣-١ x سخا ١٠٢ اقصر الهجن فى صفة طول النبات الفردى

٢-اظهرت النتائج اختلاف معنوى واضح بين السلالات والسلالات الاخوية والهجن الناتجة منهما لصفات المحصول ومكوناتة وكذالك صفات الجودة للحبوب كما جاء تباين القدرة الخاصة على التالف اعلى من القدرة العامة على التالف لكل الصفات المدروسة ما عدا صفة التزهير.

٣-لقد سجلت اعلى قيمة لقوة الهجين (٣٠.٢٤%) من التهجين بين جى زد ٨٩٥١-٩-٧-١-٣ x سخا ١٠٣ لصفة عدد الداليات بالنبات الفردى. سجلت صفة التزهير اعلى قيمة عالية المعنوية وموجبة فى درجة التوريث فى المدى الواسع بينما سجلت صصفة عدد الحبوب الممتلئة اعلى قيمة لدرجة التوريث فى المدى الضيق بينما سجلت صفة نسبة الجل ووزن ال١٠٠ حبة قيمة عالية للنسبة التقدم الوراثى.

٤-اظهرت النتائج ارتباط معنوى موجب لصفة محصول النبات الفردى مع كل من صفان النسبة المؤوية للتقشير والنسبة المؤوية للتبيض ونسبة الهد ريز وطول الحبة بعد الطهى ونسبة الجل بالحبة ودرجة الجلتنة.

توصى النتائج باستخدام الهجن التالية جى زد ٨٩٥١-٩-٧-١-٣ x سخا ١٠١ و جى زد ٨٤٥٥-٦-٨-٣-١ x سخا ١٠٤ و جى زد ٨٤٥٥-٦-٨-٣-١ x سخا ١٠١ و جى زد ٨٩٥١-٩-٧-١-٣ x سخا ١٠٣ و جى زد ٨٣٧٢-١٣-١-٣-١ x سخا ١٠٤ و جى زد ٨٣٧٢-١٣-١-٣-١ x سخا ١٠١ كافضل تراكيب وراثية لصفات المحصول والجودة للحبوب وبالتالى يمكن الاستفادة بها فى برامج التربية.

Table 1. Means of the estimated grain yield and its related characters using Lins x Testers in12 F1 rice cross combinations.

genotypes	Days to complete heading (days)	Plant height (cm)	Panicle length (cm)	No. of panicles /plant	No. of filled grains /panicle	Sterility %	100-grain weight(g)	Grain yield/plant
Line								
1- GZ-8372-13-1-3-1	111	107.2	26.1	26.4	150.2	14.1	2.6	49.2
2- GZ-8951-9-7-1-3	102	105.3	23.4	20.1	169.3	16.2	2.5	46.3
3- GZ-8455-6-8-3-1	99	96.2	25.3	24.3	172.4	18.6	2.5	48.3
Testers								
4- Sakha 101	114	98.7	25.6	22.1	162.3	15.2	2.6	44.2
5- Sakha 102	95	100.2	20.4	20.4	125.4	14.8	2.5	40.2
6- Sakha 103	90	99.3	21.8	21.3	139.4	16.3	2.5	42.3
7- sakha 104	106	109.3	23.5	21.4	145.3	15.2	2.7	43.3
Crosses								
GZ-8372-13-1-3-1 x Sakha 101	105.2	105.4	24.6	25.4	161.2	15.2	2.6	45.3
GZ-8372-13-1-3-1 x Sakha 102	100.6	100.3	22.5	25.7	134.7	14.6	2.6	42.3
GZ-8372-13-1-3-1 x Sakha 103	108.7	101.2	23.6	23.1	149.3	15.2	2.5	44.1
GZ-8372-13-1-3-1 x Sakha 104	105.4	110.3	24.6	27.5	160.5	16.4	2.7	49.2
GZ-8951-9-7-1-3 x Sakha 101	101.3	100.4	27.5	27.6	171.4	15.3	2.6	49.7
GZ-8951-9-7-1-3 x Sakha 102	100.4	102.3	26.8	25.3	142.3	13.6	2.5	43.2
GZ-8951-9-7-1-3 x Sakha 103	103.2	101.4	24.9	19.3	155.1	15.4	2.5	41.3
GZ-8951-9-7-1-3 x Sakha 104	104.3	108.9	25.4	25.7	155.4	16.5	2.6	48.9
GZ-8455-6-8-3-1 x Sakha 101	102.3	108.4	24.6	23.2	169.3	17.6	2.6	45.3
GZ-8455-6-8-3-1 x Sakha 102	96.4	98.1	24.6	23.1	144.7	16.4	2.5	42.3
GZ-8455-6-8-3-1 x Sakha 103	102.3	103.4	25.4	22.3	158.4	15.7	2.5	40.2
GZ-8455-6-8-3-1 x Sakha 104	97.2	106.3	25.1	23.3	160.2	15.2	2.6	43.2
LSD 5 %	1.3	2.4	1.0	2.1	3.2	1.2	0.2	2.4
LSD 1 %	2.4	3.6	2.3	3.4	4.2	2.1	0.6	3.2

Table 2. Means of the estimated grain quality characters using Lins x Testers in12 F1 rice cross combinations.

genotypes	Grain Shape%	Hulling %	Milling %	Head Rice %	Grain elongation %	Gel consistence	Gelatinization temperature	Amylose content %
Line								
GZ-8372-13-1-3-1	2.5	79.2	73.2	65.5	0.69	90.2	6.6	27.8
GZ-8951-9-7-1-3	2.6	82.3	74.6	66.4	0.72	86.4	6.5	19.4
GZ-8455-6-8-3-1	2.5	83.2	74.1	67.4	0.74	88.5	6.6	18.7
Testers								
Sakha 101	2.3	82.3	74.6	69.2	0.79	90.1	6.4	18.6
Sakha 102	2.4	80.2	70.1	67.4	0.71	89.7	6.2	19.2
Sakha 103	2.3	79.6	71.4	64.8	0.82	93.5	6.5	18.3
Sakha 104	2.3	81.6	73.8	68.8	0.78	91.4	6.3	16.5
Crosses								
GZ-8372-13-1-3-1 x Sakha 101	2.4	82.2	74.6	69.1	0.76	88.6	6.6	22.7
GZ-8372-13-1-3-1 x Sakha 102	2.7	81.6	72.5	68.5	0.72	85.8	6.3	25.2
GZ-8372-13-1-3-1 x Sakha 103	2.5	80.4	70.9	65.6	0.79	91.6	6.5	23.5
GZ-8372-13-1-3-1 x Sakha 104	2.5	83.4	75.3	69.4	0.75	89.8	6.3	17.2
GZ-8951-9-7-1-3 x Sakha 101	2.4	82.4	74.9	60.1	0.75	89.7	6.3	19.7
GZ-8951-9-7-1-3 x Sakha 102	2.6	81.6	72.5	67.2	0.70	87.2	6.2	19.6
GZ-8951-9-7-1-3 x Sakha 103	2.4	80.5	73.6	65.1	0.76	92.7	6.4	19.5
GZ-8951-9-7-1-3 x Sakha 104	2.5	80.2	71.3	66.8	0.75	87.3	6.3	20.2
GZ-8455-6-8-3-1 x Sakha 101	2.6	79.6	70.2	64.3	0.71	90.2	6.3	18.6
GZ-8455-6-8-3-1 x Sakha 102	2.5	80.6	74.3	62.5	0.75	86.3	6.8	17.3
GZ-8455-6-8-3-1 x Sakha 103	2.6	80.7	71.3	65.4	0.73	83.6	6.1	16.3
GZ-8455-6-8-3-1 x Sakha 104	2.3	78.3	70.2	64.6	0.72	85.2	6.8	16.3

Table 3: Analysis of variance for combining ability of rice yield and its component characters.

Source of variance	df	Days to complete heading(days)	Plant height (cm)	Panicle length (cm)	No. of panicles /plant	No. of filled grains/panicle	Sterility %	100-grain weight(g)	Grain yield/plant
Replication	2	4.25	3.21	0.54	4.36	312.25	2.13	1.24	29.65
Genotypes	18	152.38**	2134.25**	69.42**	105.34**	7322.15**	54.36**	32.25**	9954.31**
Parent	6	4287.36**	5326.41**	54.39**	100.25**	5436.28**	39.56**	23.64**	11958.24**
P vs C	1	422.35**	98.41**	325.36**	426.35**	4763.25**	29.35**	14.28**	16254.35**
Crosses	11	282.36**	726.54**	97.34**	34.28**	2637.21**	54.29**	18.24**	123531.65**
Lines	2	214.36**	356.47**	32.36**	24.31**	1546.35	44.35**	22.36**	12134.36**
Testers	3	247.56**	1236.25**	29.45**	198.34**	2263.65**	26.54**	25.14**	325471.35**
L x T	6	60.24**	40.65**	18.74**	43.26**	1974.25**	23.65**	11.74**	24532.47**
Error	36	2.31	2.57	1.24	1.83	43.71	2.21	1.34	26.27
σ^2 gca	6	44.23**	4.25**	2.36**	2.13**	29.54**	3.25**	1.02**	3771.46**
σ^2 sca	11	21.36**	15.32**	15.64**	14.27**	422.63**	13.74**	9.78**	11251.54**
σ^2 gca / σ^2 sca		2.09	0.28	0.15	0.15	0.06	0.23	0.11	0.33
Cv (%)		1.65	0.97	6.41	8.41	7.29	1.54	1.01	1.13

***and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Table 4: Analysis of variance for combining ability of rice grain quality characters.

Source of variance	df	Grain Shape%	Hulling %	Milling %	Head Rice %	Grain elongation %	Gel consistence	Gelatinization temperature	Amylose content %
Replication	2	0.28	3.58	2.84	1.97	0.52	4.97	1.94	0.41
Genotypes	18	29.23**	193.45**	158.24**	122.34**	12.35**	199.23**	32.25**	52.23**
Parent	6	21.19**	3276.16**	2211.39**	1997.15**	9.74**	5362.16**	29.47**	41.36**
P vs C	1	11.74**	323.29**	224.19**	203.15**	11.36**	497.26**	23.26**	218.34**
Crosses	11	15.32**	274.13**	179.64**	133.26	12.46**	304.26**	41.26**	83.26**
Lines	2	19.74**	197.28**	150.23**	99.25**	19.72**	250.27**	32.26**	24.36**
Testers	3	20.43**	213.69**	199.27**	123.25**	20.71**	272.36**	19.74**	20.29**
L x T	6	9.25**	49.28**	35.26**	29.74**	8.23**	64.36**	17.62**	13.29**
Error	36	2.06	2.11	1.97	2.31**	0.36	3.25	1.49	1.32
σ^2 gca	6	2.13**	14.36**	11.41**	8.26	0.21**	49.72**	1.26**	3.16**
σ^2 sca	11	8.41**	25.36**	22.14**	19.74	3.26**	33.26**	10.94**	14.87**
σ^2 gca / σ^2sca		0.25	0.56	0.53	0.42	0.06	1.48	0.11	0.21
Cv (%)		3.12	2.87	6.24	5.29	1.97	6.82	1.79	7.26

***and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Table 5. General combining ability (GCA) effects of yield and its component characters in rice.

genotypes	Days to heading (days)	Plant height (cm)	Panicle length (cm)	No. of panicles /plant	No. of filled grains /panicle	Sterility %	100-grain weight(g)	Grain yield/plant
Lines								
GZ-8372-13-1-3-1	5.23**	3.17**	-1.84	-1.47	-5.34	2.24*	0.87	2.14*
GZ-8951-9-7-1-3	-4.97**	-5.43**	1.39	2.56**	12.36	3.57**	1.63	3.57**
GZ-8455-6-8-3-1	-1.03	2.24**	-0.47	-1.11*	7.12**	1.33	-0.26	-1.43*
SE (*ig*)	0.27	0.38	0.82	0.73	-1.43	0.98	0.12	0.24
Testers								
Sakha 101	-11.32**	-10.47**	-1.29*	2.41**	22.34**	-8.47**	3.41**	1.68**
Sakha 102	3.54**	-11.78**	4.26**	-5.26**	-7.26**	-11.25**	-4.72**	-5.49**
Sakha 103	5.35**	5.41**	1.79*	-2.84**	-69.45**	3.97*	-2.79*	1.36*
Sakha 104	19.28**	16.38**	-4.39	-5.97**	40.28**	15.42**	3.47**	3.27**
SE (*ig*)	0.96**	0.72	0.46	0.54	1.97	0.83	0.27	0.53

***and ** significant at 0.05 and 0.01 probability levels, respectively.**

Table 6. General combining ability (GCA) effects of grain quality characters in rice.

genotypes	Grain Shape%	Hulling %	Milling %	Head Rice %	Grain Elongation %	Gel Consistence	Gelatinization Temperature	Amylose content %
Lines								
GZ-8372-13-1-3-1	0.63	4.12**	-3.26**	2.97**	0.63**	2.97**	-2.31**	3.26**
GZ-8951-9-7-1-3	1.25	-3.62**	4.39**	3.26**	0.96**	5.26**	1.97**	-6.97**
GZ-8455-6-8-3-1	0.63	-1.13	-1.97**	0.29	0.33*	2.25**	1.25*	2.95**
SE (*ig*)	0.14	0.37	0.42	0.32	0.05	1.35	1.11	1.02
Testers								
Sakha 101	-1.16**	9.74**	8.27**	-4.41**	2.25**	10.41**	3.15**	-4.28**
Sakha 102	-3.54**	-10.74**	9.74**	-6.34**	2.24**	9.63**	5.74**	6.27**
Sakha 103	-2.16**	-11.62**	5.97**	2.18**	-1.69**	-4.25**	4.31**	8.54**
Sakha 104	6.29**	12.63**	12.63**	8.47**	-3.25**	-15.26**	-7.25**	-10.26**
SE (*ig*)	0.43	0.54	0.64	0.51	0.11	2.36	0.84	1.45

***and ** significant at 0.05 and 0.01 probability levels, respectively.**

Table 7. Specific combining ability (SCA) effects for grain yield and its component characters in rice crosses.

genotypes	Days to complete heading(days)	Plant height (cm)	Panicle length (cm)	No. of panicles /plant	No. of filled grains /panicle	Sterility %	100-grain weight(g)	Grain yield/plant
GZ-8372-13-1-3-1 x Sakha 101	3.26*	-2.97*	2.36**	5.89**	11.47**	-1.53	0.45	9.25**
GZ-8372-13-1-3-1 x Sakha 102	2.63	4.36**	-1.45	-25.67**	-14.63**	5.47**	-3.27**	-86.45**
GZ-8372-13-1-3-1 x Sakha 103	7.41**	2.57*	1.97**	1.97	-5.46**	1.29	0.92	-63.25**
GZ-8372-13-1-3-1 x Sakha 104	-6.26**	-7.41**	0.09	2.86*	22.47**	-2.64**	1.46*	10.26**
GZ-8951-9-7-1-3 x Sakha 101	2.97*	2.96*	1.53*	7.58**	9.41**	1.11	0.84	-54.23**
GZ-8951-9-7-1-3 x Sakha 102	-1.29	-4.21**	-1.09	11.17**	-4.26**	0.96	0.12	35.26**
GZ-8951-9-7-1-3 x Sakha 103	-4.25**	0.69	-1.28*	-26.82**	3.97*	0.79	0.28	64.24**
GZ-8951-9-7-1-3 x Sakha 104	2.69*	-3.25*	2.84**	29.74**	19.74**	0.46	0.32	120.36**
GZ-8455-6-8-3-1 x Sakha 101	2.84	3.17*	-1.92**	-12.15**	9.74**	-1.97**	0.89	50.38**
GZ-8455-6-8-3-1 x Sakha 102	-0.84	-1.26	0.97	-2.36*	-9.87**	6.42**	3.96**	-49.28**
GZ-8455-6-8-3-1 x Sakha 103	1.97	2.45*	-2.43	21.47**	-8.27**	0.53	0.34	-110.34**
GZ-8455-6-8-3-1 x Sakha 104	3.25**	5.27**	2.63**	12.62**	9.45**	-2.97**	1.84*	102.36**
SE (*ijs*)	1.22	1.63	0.65	2.63	1.98	0.84	0.14	3.12

***and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Table 8. Specific combining ability (SCA) effects for grain quality characters in rice crosses.

genotypes	Grain Shape%	Hulling %	Milling %	Head Rice %	Grain elongation %	Gel consistence	Gelatinization temperature	Amylose content %
GZ-8372-13-1-3-1 x Sakha 101	0.64	2.26*	2.54*	2.03**	0.12	3.41*	-1.47	2.47
GZ-8372-13-1-3-1 x Sakha 102	-2.97**	-4.96**	-1.22	-1.69*	-1.42**	5.26**	3.52**	4.25**
GZ-8372-13-1-3-1 x Sakha 103	-0.82	-3.74***	-1.36	-1.23	0.37	-3.97**	-1.46	-2.35
GZ-8372-13-1-3-1 x Sakha 104	2.41**	9.72**	3.74**	2.97**	-1.26**	7.29**	3.54**	4.89**
GZ-8951-9-7-1-3 x Sakha 101	0.63	4.26**	1.27	-1.12	0.32	-3.71**	-1.26	2.48
GZ-8951-9-7-1-3 x Sakha 102	-0.14	-5.41**	-1.11	-0.99	0.11	-4.21**	-1.21	-2.41
GZ-8951-9-7-1-3 x Sakha 103	-0.46	-1.09	-1.16	-1.12	0.23	-2.36	-1.97	-3.25**
GZ-8951-9-7-1-3 x Sakha 104	0.39	-3.97**	-3.25**	3.08**	0.21	-3.27**	1.28	-2.97*
GZ-8455-6-8-3-1 x Sakha 101	0.97	4.21**	3.74**	2.41**	0.31	4.25**	-2.31	3.28**
GZ-8455-6-8-3-1 x Sakha 102	-4.26**	-1.22	0.98	-1.84	1.97**	-2.41	3.47**	4.61**
GZ-8455-6-8-3-1 x Sakha 103	0.94	-3.25**	-2.49	-2.83	0.36	-3.69**	-2.09	-3.97**
GZ-8455-6-8-3-1 x Sakha 104	2.09**	6.41**	5.41**	4.21**	1.25**	5.97**	-3.97**	-5.42**
SE (*ijs*)	0.12	1.84	1.03	0.97	0.04	2.08	0.48	1.42

***and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Table 9. Estimates of Heterobeltiosis (Hb) for yield and its component characters in rice crosses.

genotypes	Days to complete heading (days)	Plant height (cm)	Panicle length (cm)	No. of panicles /plant	No. of filled grains /panicle	Sterility %	100-grain weight(g)	Grain yield/plant
GZ-8372-13-1-3-1 x Sakha 101	0,96	7,14**	-4.26**	3,84**	-0,61	7,14**	-1,51	-8,16**
GZ-8372-13-1-3-1 x Sakha 102	5,26**	-0,19	-4,34**	-3,84**	-10,66**	-1,40	1,15	-14,28**
GZ-8372-13-1-3-1 x Sakha 103	6,93**	2,02	-2,95	-11,53**	-0,66	7,14**	-3,46**	-10,20**
GZ-8372-13-1-3-1 x Sakha 104	1,48	2,80*	4,34**	-23,07**	-9,33**	14,28**	3,33**	6,60**
GZ-8951-9-7-1-3 x Sakha 101	-1,46	2,04	3,84**	22,72**	1,18	-5,06**	1,15	2,08**
GZ-8951-9-7-1-3 x Sakha 102	5,26**	2.12	-1,51	25.45**	-15,96**	-7,14**	0,42	-10,41**
GZ-8951-9-7-1-3 x Sakha 103	1,98	2,02	-7,69**	30.24**	-8,28**	-6,25**	1,64	-14,58**
GZ-8951-9-7-1-3 x Sakha 104	1,96	2,85*	-2,34	-5.63**	-20,11**	6,66**	-2,59*	-2,04
GZ-8455-6-8-3-1 x Sakha 101	3,03**	-12,5**	-4.32**	-4,16**	-1,74	13,33**	1,15	-2,17
GZ-8455-6-8-3-1 x Sakha 102	3,15**	2,08	-4.54**	-4,16**	-16,27**	14,28**	0,43	-8,69**
GZ-8455-6-8-3-1 x Sakha 103	3,03**	7,29**	-1,57	-8,33**	-8,13**	-1,96	2,46	-13,04**
GZ-8455-6-8-3-1 x Sakha 104	-2,02*	-10,41**	-2,34	-4,16**	-6,97**	-6,25**	-2,22	-10,41**

***and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Table 10. Estimates of Heterobeltiosis (Hb) for grain quality characters in rice crosses.

genotypes	Grain Shape%	Hulling %	Milling %	Head Rice %	Grain elongation %	Gel consistence	Gelatinization temperature	Amylose content %
GZ-8372-13-1-3-1 x Sakha 101	-7,69**	-0,48	1,36*	0,43	-11,39**	-2,22	3,12**	22,22**
GZ-8372-13-1-3-1 x Sakha 102	3,84**	1,25*	-1,34*	-0,29	-1,40	-5,55**	1,61	31,57**
GZ-8372-13-1-3-1 x Sakha 103	-3,84**	1,26*	-4,10**	-4,41**	-3,65**	-2,15	1,56	27,77**
GZ-8372-13-1-3-1 x Sakha 104	-3,84**	-1,23*	1,35*	1,47	-3,84**	-2,19	1,58	6,25**
GZ-8951-9-7-1-3 x Sakha 101	-4.26**	1,21*	-0,40	-1,44	-5,06**	-1,11	-1,56	-2,56
GZ-8951-9-7-1-3 x Sakha 102	4.34**	-1,21	-2,71**	-7,95**	-2,77*	-2,24	-1,58	-1,55
GZ-8951-9-7-1-3 x Sakha 103	-4.87**	-2,43**	-1,35	-0,61	-7,31**	-1,07	-1,53	5,55**
GZ-8951-9-7-1-3 x Sakha 104	-3,10**	-2,41**	-4,05**	-2,94	-3,84**	-4,39**	-0,78	25.31**
GZ-8455-6-8-3-1 x Sakha 101	8,33**	4,81**	5,40**	14,47**	-10,12**	-0,55	6,25**	-5,70**
GZ-8455-6-8-3-1 x Sakha 102	4,16**	-1,20	-1,20	-7,46**	7,35	3,37**	1.58	-2,55
GZ-8455-6-8-3-1 x Sakha 103	8,33**	-3,61**	-4,05**	-2,98	-10,97**	-10,75**	-1,61	5,55**
GZ-8455-6-8-3-1 x Sakha 104	-4,16**	-6,02**	-5,40**	-4,47**	-7,69**	-6,59**	4,61**	-3,03**

***and ** significant at 0.05 and 0.01 levels of probability, respectively.**